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IMPROVED MORPHOLOGICAL BACKGROUND DETECTION AND ENHANCEMENT OF IMAGES BASED ON WEBER'S LAW

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ABSTRACT

Weber's law suggests a logarithmic relationship between perceptual stimuli and human perception. The Weber sampler is an adaptive, non uniform sampling mechanism that exploits Weber's law to sample the signal at a minimum rate without significant perceptual degradation. In this paper, we introduce Morphological transformation and Block analysis is used to detect the background of gray level and color images. These techniques are first implemented in gray scale and then extended to color images by individually enhancing the color components. Some morphological transformations are used to detect the background in color images characterized by poor contrast. Contrast operators are based on the logarithm function in a similar way to Weber's law. The use of the logarithm function avoids abrupt changes in lighting. The first method employs information from image background analysis by blocks, while the second transformation method utilizes the opening operation, closing operation, which is employed to define the multi-background color images. The results of each technique are illustrated for various backgrounds, majority of them in poor lighting condition. The complete image processing is done using JAVA simulation model.

KEYWORDS: Morphological Transformation and Block Analysis, JAVA Simulation Model, Weber's Law

I. INTRODUCTION

Image enhancement is a challenging research area in image processing. Its principal objective is to process an image so that the result is more suitable than the original image for a specific application. There are several techniques to enhance an image. Image enhancement is a technique that increases the visual contrast of an image in a designated intensity range or ranges. The background in poor lighting of various grey scale images and color images can be identified by the use of morphological operators. Then image enhancement has been carried out by the application based on Weber's law. Thereafter erosion, dilation and opening by reconstruction method is followed [1].

In this work, two methodologies to compute the image background are proposed. Also, some operators to enhance and normalize the contrast in grey level images and color images with poor lighting are introduced. Contrast operators are based on the logarithm function in a similar way to Weber's law. The use of the logarithm function avoids abrupt changes in lighting. Also, two approximations to compute the background in the processed images are proposed. The first proposal consists in an analysis by blocks, whereas in the second proposal, the opening by reconstruction is used given its following properties: a) it passes through regional minima, and b) it merges components of the image without considerably modifying other structures. The proposals given in this paper are illustrated with several examples.

Finally, this paper is organized as follows. Section II, Contrast enhancement. Section III, presents morphological Transformations. Section IV, gives Weber's law. Section V, Image background detection by block analysis. Section VI,

Image background determination using opening by reconstruction. Section VII, Histogram equalization. Section VIII, Experimental analysis. Finally, conclusions are presented in Section IX.

II. CONTRAST ENHANCEMENT

Contrast is the opposition or dissimilarity of things that are compared ,extent to which adjacent areas on the image differ in brightness. Contrast is act of distinguishing by comparing differences. Contrast refers to how bright the highlights are while brightness refers to how bright the shadows are. For example, if you had a dark rectangle and light rectangle in the image, the brightness setting will affect the dark rectangle and contrast setting will affect the light rectangle. If both brightness and contrast are set to minimum, the screen will be pure black [2].

The image enhancement includes the improvement of the visibility and perceptibility of the various regions, in which an image can be partitioned and defect ability of the image features inside the regions. Image enhancement is usually followed by detection of features such as edges, peaks, and other geometric features which is of paramount importance in low-level vision. One can see that the enhanced image is a shaper image than the original. Particularly interesting is the fact that textural information has been rendered visible in the enhanced image [3] [4].

III. MORPHOLOGICAL TRANSFORMATION

Morphology

Morphology is a technique of image processing based on shapes. The value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. By choosing the size and shape of the neighborhood, morphological operation can be constructed that is sensitive to specific shapes in the input image [5].

Mathematical morphology is a set-theoretical approach to multi-dimensional digital signal or image analysis, based on shape. It is a theory and technique for the analysis and processing of geometrical structures, based on set_theory, lattice theory, topology, and random functions. It is most commonly applied to digital images, but it can be employed as well on graphs, surface meshes, solids, and many other spatial structures [6].

It is also the foundation of morphological image processing, which consists of a set of operators that transform images according to the above characterizations. Mathematical morphology was originally developed for binary_images, and was later extended to scale functions and images. The subsequent generalization to complete_lattices is widely accepted today as MM's theoretical foundation.

Morphological Transformations

Basically morphological transformations such as erosion, dilation, opening and closing are used to detect the background.

Erosion

Erosion is one of the two basic operators in the area of mathematical morphology, the other being dilation. It is typically applied to binary images, but there are versions that work on gray scale images. The erosion operator takes two pieces of data as inputs. The first is the image which is to be eroded. The second is a (usually small) set of coordinate points known as structuring elements (also known as a kernel). It is this structuring element that determines the precise effect of the erosion on the input image. In erosion, every object pixel that is touching a background pixel is changed into a background pixel.

Gray scale erosion with a flat disk shaped structuring element will generally darken the image. Bright regions surrounded by dark regions shrink in size, and dark regions surrounded by bright regions grow in size. Small bright spots in images will disappear as they are eroded away down to the surrounding intensity value, and small dark spots will become larger spots. The effect is mostly marked at places in the image where the intensity changes rapidly, and regions of fairly uniform intensity will be left more or less unchanged except at their edges [7].

Dilation

Dilation adds pixels to the boundaries of objects in an image. In dilation, every background pixel that is touching an object pixel is changed into an object pixel. Note how the function applies the rule to the input pixel's neighborhood and uses the highest value of all the pixels in the neighborhood as the value of the corresponding pixel in the output image [8]. The dilation operator takes two pieces of data as inputs. The first is the image which is to be dilated. The second is a (usually small) set of coordinate points known as a structuring element (also known as a kernel). It is this structuring element that determines the precise effect of the dilation on the input image. To compute the dilation of a binary image by structuring element, Each of the background pixels in the input image in turn is considered. For each background pixel, the structuring element coinciding with the input pixel position is superimposed.

IV. WEBER'S LAW

Weber's law states that, it is the ratio of the difference in maximum to minimum luminance value to the minimum luminance value and it is denoted by C [9].

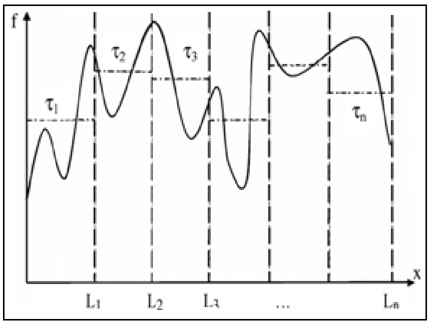

Figure 1

$$C = \frac{L_{max} - L_{min}}{L_{min}} \qquad (1)$$

If $L = L_{min}$ $\Delta L = L_{max} - L_{min}$

can be rewritten as

$$C = \frac{\Delta L}{L}$$

This indicates $\Delta(\text{Log } L)$ is proportional to C; therefore,

Weber's law can be expressed as

$$C = k \log L + b \quad L > 0 \qquad (2)$$

Where, k and b are constants, b being the background.

V IMAGE BACKGROUND DETECTION BY BLOCK ANALYSIS

In this analysis, first of all an image will be read as input image and divided into several blocks and from each block ,the background will be determined and after applying the Weber's law , an enhanced image will be obtained [10].

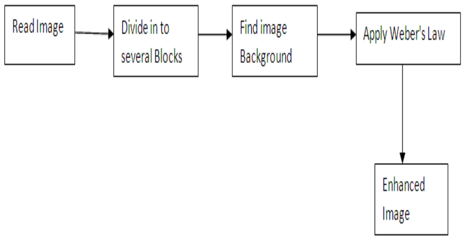

Figure 2: Block Diagram of Background Detection by Block Analysis

Let us consider an image which is to be enhanced. The image is divided into n blocks of size. Each block is a sub image of the original image. As the image is made up of number of pixels each block consists of number of pixels. Find the maximum and minimum intensity values of pixels of each block [11].

For each analyzed block, maximum (M_i) and minimum (m_i) values are used to determine the background criteria T_i in the following way:

$$\tau_i = \frac{m_i + M_i}{2} \qquad \forall i = 1,2,\_\_\_ n \tag{3}$$

Figure 2 Background criteria obtained by block analysis

In the 1-D case, as illustrated in Figure 2, the following expression is obtained:

Once T_i is calculated, this value is used to select the background parameter associated with the analyzed block. As follows, an expression to enhance the contrast is proposed:

$$\Gamma\tau_i(f) = \begin{cases} k_i \log(f+1) + M_i, & f \le \tau_i \\ k_i \log(f+1) + m_i, & \text{otherwise} \end{cases} \tag{4}$$

Note that the background parameter depends on the T_i value. If f<= T_i (dark region), the background parameter takes the value of the maximum intensity (M_i) within the analyzed block, and the minimum intensity (m_i) value otherwise. Also, the unit was added to the logarithm function in above equation to avoid indetermination [12]. On the other hand, since grey level images are used in this work, the constant K_i in above equation is obtained as follows:

$$k_i = \frac{255 - m_i}{\log(256)} \qquad \forall_i = 1,2,\ldots.n \tag{5}$$

$$m_i = \begin{cases} m_i, & f > \tau_i \\ M_i, & f \le \tau_i \end{cases} \tag{6}$$

On the other hand, $M_{i.}$ and m_i values are used as background parameters to improve the contrast depending on the T_i value, due to the background is different for clear and dark regions. Now an image is formed by applying the equation number 6. Now consider a pixel in this image and the corresponding pixel in original image. Combine them using Weber's law which can be stated as follows. Thus, an enhanced image is formed [13][14].

VI. IMAGE BACKGROUND DETERMINATION USING OPENING BY RECONSTRUCTION

On the other hand, given that, maximum and minimum values are analyzed for each block, an extension using morphological operators is presented as follows.

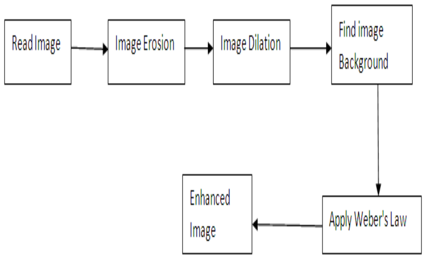

Figure 3: Block Diagram of Background Detection by Erosion & Dilation

In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. By choosing the size and shape of the neighborhood, a morphological operation can be constructed that is sensitive to specific shapes in the input image. Dilation and erosion are two fundamental morphological operations. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image[15] [16].

In erosion, every object pixel that is touching a background pixel is changed into a background pixel. Dilation adds pixels to the boundaries of objects in an image. In dilation, every background pixel that is touching an object pixel is changed into an object pixel. Note how the function applies the rule to the input pixel's neighborhood and uses the highest value of all the pixels in the neighborhood as the value of the corresponding pixel in the output image.

Let $I_{\max}$(x) and $I_{\min}$ (x) be the maximum and minimum intensity values taken from one set of pixels contained in a window (B) of elemental size (3 X 3 elements), x belongs to D. Notice that the window corresponds to the structuring element .A new expression can be derived as shown:

$$\tau(x)=\frac{I_{\min}(x)+I_{\max}(x)}{2} \tag{7}$$

Where $I_{\max}$(x) and $I_{\min}$ (x) values correspond to the morphological dilation and erosion defined by the order-statistical filters. Thus, the above expression is expressed as

$$\tau(x)=\frac{\in_{\mu}(f)(x)+\delta_{\mu}(f)(x)}{2} \tag{8}$$

Finally the proposed transformation is expressed ass

$$\Gamma_{\tau(x)}(f)=\begin{cases} k_{\tau(x)}\log(f+1)+\delta_{\mu}(f)(x), & f\le\tau(x) \\ k_{\tau(x)}\log(f+1)+\in_{\mu}(f)(x), & \text{otherwise} \end{cases}$$

$$\text{and } k_{\tau(x)}=\frac{255-\tau(x)}{\log(256)} \tag{9}$$

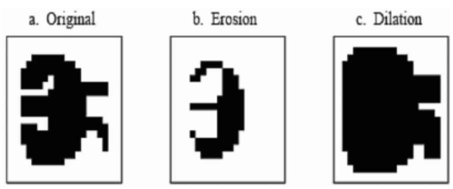

Figure 4: a) Original Image b) Erosion c) Dilation

VII. HISTOGRAM EQUALIZATION

Histogram equalization is one of the well known image enhancement technique. It became a popular technique for contrast enhancement because this method is simple and effective. In the latter case, preserving the input brightness of the image is required to avoid the generation of non-existing artifacts in the output image. Although these methods preserve the input brightness on the output image with a significant contrast enhancement, they may produce images which do not look as natural as the input ones. The basic idea of histogram equalization method is to re-map the gray levels of an image. Histogram equalization tends to introduce some annoying artifacts and unnatural enhancement.

This technique is widely used to improve images with poor lighting. The histogram equalization technique consists in reordering the grey level intensities within the image to obtain a uniformly distributed histogram [17][18].

VIII. EXPERIMENT RESULT ANALYSIS AND DISCUSSION

The proposed method for enhancing the various poor lighting images have been implemented using JAVA tool. The result of each method are analysed by using statistical parameter. The detailed descriptions are given below.

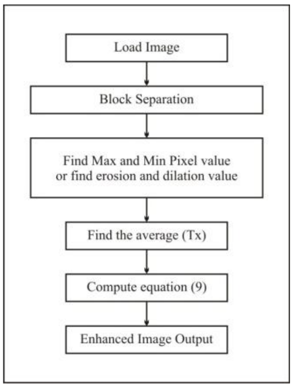

Figure 5: The Architecture of the Proposed System Following Code Convert Image to Black &White Image

```
public void process1()
        {
  mv=new double[height][width];
      int xi=0,yi=0;
for (int i=0;i<a. length;i++)
                {
mv[yi][xi]=(red[i]+green[i]+blue[i])/3.0;
xi++;
if(xi==width)
  {
  yi++;
  xi= 0;
  }
```

```
        }
    for (int cy=bksize;cy<height-bksize;cy+=bksize*2)
      {
      for (int cx=bksize;cx<width-bksize;cx+=bksize*2)
          {
          double maxv=mv[cy][cx];
          double minv=mv[cy][cx];
          for(int y=-bksize;y<bksize;y++)
             for(int x=-bksize;x<bksize;x++)
               {
               if(mv[cy+y][cx+x]>maxv)
                 maxv=mv[cy+y][cx+x];
               if(mv[cy+y][cx+x]<minv)
                 minv=mv[cy+y][cx+x];
               }
          double meanv=(maxv+minv)/2.0;
          for(int y=-bksize;y<bksize;y++)
             for(int x=-bksize;x<bksize;x++)
               {
          double k;
          if(meanv>=mv[cy+y][cx+x] )
                {
             k= (255-maxv)/Math. log(256);
             mv[cy+y][cx+x]=k*Math.log(mv[cy+y][cx+x]+1)+maxv;
             }
          else
            {
            k=(255-minv)/Math.log(256);
            mv[cy+y][cx+x]=k*Math.log(mv[cy+y][cx+x]+1)+minv;
                  }      }      }      }
```

// **following code for reconstruct image**

```
for (int i=0;i<a.length;i++)
      {
      yi= i/width;
      xi= i%width;
      a [i]=alpha[i];
      a [i]=a[i]<<8;
      a [i]=a[i]|(int)mv[yi][xi];
     a[i]=a[i]<<8;
    a [i]=a[i]|(int)mv[yi][xi];
    a[i]=a[i]<<8;
    a [i]=a[i]|(int)mv[yi][xi];
    }
bimg=new
BufferedImage(width,height,BufferedImage.TYPE_INT_ARGB);
bimg.setRGB(0,0,width,height,a,0,width);
img=new ImageIcon(bimg);
lblresult.setIcon(img);
}
public void process2()
          {
int xi,yi;
for (int cy=bksize;cy<height-bksize;cy+=bksize*2)
      {
for (int cx=bksize;cx<width-bksize;cx+=bksize*2)
      {
      double maxv=mv[cy][cx];
      double minv=mv[cy][cx];
      for(int y=-bksize;y<bksize;y++)
          for(int x=-bksize;x<bksize;x++)
              {
              if(mv [cy+y][cx+x]>maxv)
```

```
            maxv=mv[cy+y][cx+x];
          if(mv[cy+y][cx+x]<minv)
            minv=mv[cy+y][cx+x];
          }
      double meanv=(maxv+minv)/2.0;
      for(int y=-bksize;y<bksize;y++)
         for(int x=-bksize;x<bksize;x++)
            {
            double k;
            if(meanv>=mv[cy+y][cx+x] )
              {
               k=(255-maxv)/Math.log(256);
         mv[cy+y][cx+x]=k*Math.log(mv[cy+y][cx+x]+1)+maxv;
               }
            else
              {
              k=(255-minv)/Math.log(256);
         mv[cy+y][cx+x]=k*Math.log(mv[cy+y][cx+x]+1)+minv;
              }   }
              }    }
```

The logical descriptions are given below

- Preprocess to get data from image (i.e. color data retrieve of image)
- Pixelgrabber retrieve image data in 1 D array.
- R G B component are now separated
- Converts RGB into Black & White. This data is linear data (1 D data)
- For image processing ,converts it into 2D
- For each pixel, gets (Known) min & max value of surrounding pixel.

  Meanv= (maxv+minv)/2.0
- For each pixel , value mv is greater or min
- If max K=(255-maxv), Ifless K=(255-minv)

IX. CONCLUSIONS

This paper presents the method to detect the image background and to enhance the contrast in grey level images with poor lighting. First, a methodology was introduced to compute an approximation to the background using blocks analysis. This proposal was subsequently extended using mathematical morphology operators. However, a difficulty was detected when the morphological erosion and dilation were employed, therefore, a new methodology to detect the image background was propounded, that is based on the use of morphological connected transformations.

Also, morphological contrast enhancement transformations were introduced. Such operators are based on Weber's law notion. These contrast transformations are characterized by the normalization of grey level intensities, avoiding abrupt changes in illumination. The performances of the proposals provided in this work were illustrated by means of several examples throughout the paper. Also, the operators performance employed in this paper were compared with others given in the literature. Finally contrast enhancement transformations studied in this paper is that they can only be used satisfactorily in images with poor lighting.

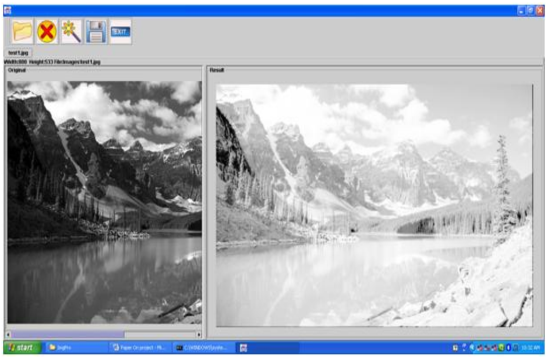

Figure 6: a) Original Image b) Output Image

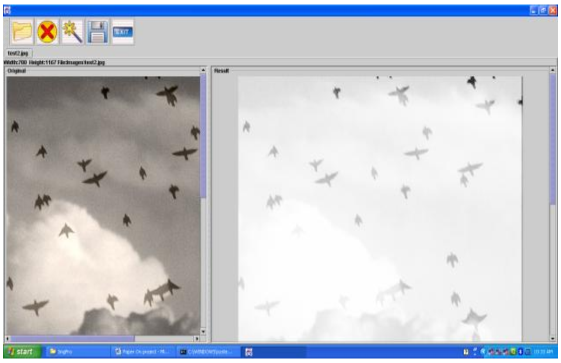

Figure 7: a) Original Image b) Output Image

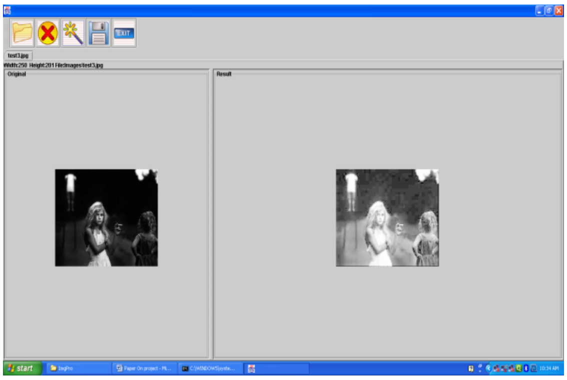

Figure 8: a) Original Image b) Output Image

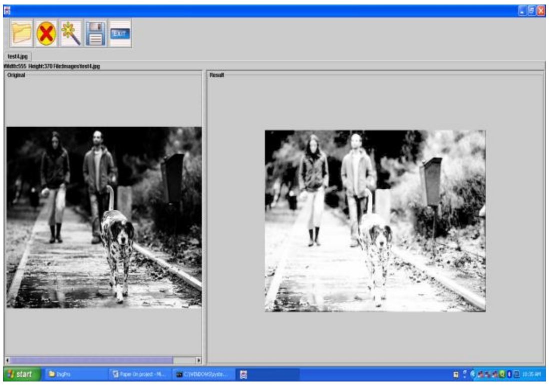

Figure 9: a) Original Image b) Output Image

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